

Delta Science Program

DELTA SCIENCE PROGRAM INDEPENDENT SCIENCE REVIEW

Fall Low Salinity Habitat (FLaSH) Study Synthesis – Year One of the Delta Fall Outflow Adaptive Management Plan

Review Panel Summary Report

Review Panel Members:

Denise J. Reed, *Panel Chair*
Department of Earth and
Environmental Sciences
University of New Orleans

Ernst B. Peebles
College of Marine Science
University of South Florida

Arturo S. Leon
School of Civil and
Construction Engineering
Oregon State University

William V. Sobczak
Department of Biology
College of the Holy Cross

Hans W. Paerl
Institute of Marine Sciences
University of North Carolina -
Chapel Hill

Eric B. (Rick) Taylor
Department of Zoology
Beaty Biodiversity Centre
University of British Columbia

Delta Science Program Liaison: George Isaac

September 4, 2012

Table of Contents

Executive Summary	ii
1. INTRODUCTION	1
1.1 Background.....	1
1.2 Progress Since the 2011 Review.....	2
2. COMMENTS ON THE DRAFT 2012 FLASH STUDY REPORT	2
3. COMMENTS ON THE ADAPTIVE MANAGEMENT PLAN	4
3.1 General Strategy.....	4
3.2 Field Measurements.....	6
3.3 Long-Term Integration and Learning	8
3.2 Response Variables.....	12
4. PERSPECTIVES ON SPECIAL STUDIES.....	12
4.1 Turbidity Studies.....	12
4.2 Trophic Analyses.....	13
5. SUMMARY CONCLUSIONS	15
6. REFERENCES	17
Appendix I: Scientific Review Panel Charge and Materials	
Appendix II: Agenda for Independent Science Review	

Executive Summary

In 2008, the US Fish and Wildlife Service (Service) issued a Biological Opinion (BiOp) on Central Valley Project (CVP)/State Water Project (SWP) operations that called for the use of adaptive management (AM) concerning fall Delta outflow (Fall outflow) in certain water-year types in part to improve habitat for endangered Delta Smelt (DS). The BiOp calls for Delta outflow to be managed such that in September and October, X2¹ averages 74 km when the water year was classified as “wet,” or 81 km when the year was classified as “above normal.” In all other water-year types, no manipulative action is taken. 2011 was the first wet year after the BiOp was issued, and thus an integrated set of studies was initiated (Fall Low Salinity Habitat, or FLASH studies) to provide information regarding the nature and mode of action of changes in the position of Fall Low Salinity Habitat and subsequent effects on DS health and abundance.

A panel of independent scientists (Panel) was convened to review the existing AM results and synthesis, as well as plans for future AM activities (draft 2012 Adaptive Management Plan, or AMP), to ensure these are of sufficient robustness and scientific quality to reliably serve their intended purposes. The Panel was impressed by the level of coordination and research effort that the FLASH team achieved in their study of the 2012 Fall outflow event. It was an impressive mobilization of field researchers that demonstrated professional, collegial collaboration among different research groups working toward a common goal. It was clear that several recommendations of the 2011 review Panel had been adopted while investigating this Action.

The Panel developed the following recommendations:

Recommendation 1: Develop a schematic version of the Conceptual Model (CM) that matches the revised, written version of the CM in the draft 2012 FLASH study report. The CM in written and schematic form should continue to emphasize processes and their interactions over statistical relationships, should ensure DS vital rates remain central to thinking, and should be designed for routine use by scientists as an organizational tool and for testing hypotheses associated with the AMP; it should be as complex as necessary to achieve these purposes. The CM should also be able to encompass processes and interactions that extend before and after Fall Outflow Action periods, including areas both upstream and downstream of the Low Salinity Zone (LSZ).

Recommendation 2: Begin a discussion of a definition of “success” for the Fall Outflow action. Various partners in the DS AMP team should try to arrive at consensus on an appropriate target for DS population metrics or vital rates related to the Fall Outflow action. For instance, demographic trends for DS are well summarized in the

¹X2 is the location (km) of the 2 ppt isohaline at estuary bottom, measured upstream from the Golden Gate bridge, as in Jassby et al. (1995).

draft 2012 FLASH study report, but neither that report nor the proposed AMP contain a target population size or range of population sizes that would define successful for this action alone or within the context of other actions being undertaken under the BiOp. This lack of a target will make it difficult to assess the long-term success of the program, especially in Action years when any positive demographic response of DS will need to be evaluated against the costs of reduced water availability for other uses.

Recommendation 3: Develop a simple decision matrix that identifies data collection and analysis objectives for Action years (wet and above normal years) and Non-Action years. The decision matrix should not necessarily be used only once per year, but should instead be designed to identify the earliest point in time at which commitments can be made to specific tasks. For example, planning for routine monitoring can start much earlier than planning for tasks that depend on recent outflow history, but it would be better to start planning for the latter as soon as the water year type is determined.

Recommendation 4: Use an interactive approach to develop long-term plans for monitoring and study during each water year type, and place a greater emphasis on integration of results in the AMP. Relationships within the CM should be evaluated across broad levels of variation (i.e., strive to obtain both end-member and intermediate observations). Examine existing data to determine how the distribution of observations can be improved for any given parameter. Ask “what processes do we need to learn about next?” and “can we get information during Non-Action years?”

Recommendation 5: Determine where improvements to spatial or temporal resolution are warranted. The use of remote sensing, continuous recorders, and other means of obtaining higher-resolution data may reveal parameter variations that are not evident from monthly grab samples. Use the CM to focus on what is important to resolve in more detail (i.e., variables that are central to underlying hypotheses); however, do not needlessly expend resources on improving resolutions that are not justified. Identify key locations for continuous measurements.

Recommendation 6: Identify opportunities to coordinate and integrate field measurements. The objectives of this effort are (1) to improve field sampling efficiencies and cost effectiveness and (2) to provide additional and complementary spatial and temporal resolution of linkages among the key physical, chemical, geological and biological parameters identified in the CM. These two objectives will help facilitate Recommendation 5.

Recommendation 7: Organize the leadership of the AMP. Determine who “owns” the AMP and its conceptual development (beyond the coordination of the field effort). Assign magnitude to the Action in terms of water costs and funding costs, and *identify and employ a Chief Scientist*. A person who serves as a common repository for information on field activities will facilitate the preceding recommendations.

Recommendation 8: Start planning now for future modeling needs. The ultimate goal of the AMP and associated research is improved prediction of biological response of DS in response to Delta outflow manipulation. However, development of numerical models is beyond the present scope and should be regarded as a parallel effort that will be supported by the improved CM. The improved CM will identify the key pathways and linkages that need to be modeled numerically, leading to integrated numerical modeling in the future. Whenever possible, participants in the AMP should plan beforehand for modeling needs that will arise in the future.

Recommendation 9: Develop plans to account for uncertainty. Dynamic ecosystems mean uncertainty is always present, yet some parameters are more certain than others. AMP participants should design studies/monitoring that will reduce uncertainty, and account for uncertainty in assessments and predictions whenever possible.

Recommendation 10: The AMP should incorporate monitoring of response variables that have a clear demographic linkage to DS, both at the individual and population level (e.g., otolith inferred growth rates, fecundity, condition factor). This is a restatement of an important recommendation (No. 14) from the previous Panel report.

1. INTRODUCTION

1.1 *Background*

In 2008, the US Fish and Wildlife Service (Service) issued a Biological Opinion (BiOp) on Central Valley Project (CVP)/State Water Project (SWP) operations that called for the use of adaptive management (AM) concerning fall Delta outflow (Fall outflow) in certain water-year types. The resultant Fall outflow action (Action) was expected to improve habitat suitability and contribute to higher average delta smelt (DS) abundances; the DS is an endangered species that is endemic to the Sacramento-San Joaquin river and estuarine system. The Action is defined by the Reasonable and Prudent Alternative (RPA) that was issued with the BiOp, which calls for Delta outflow to be managed such that in September and October, X2² must average 74 km when the water year containing the preceding spring was classified as “wet,” or 81 km when the preceding spring was classified as “above normal.” In all other water-year types (Non-Action years), the RPA is not implemented. Further, the performance of the Action shall be investigated using a research and monitoring program that contains a feedback loop, allowing the Action to be adjusted from learned information (i.e., adaptive management). The US Bureau of Reclamation (Reclamation) expects application of this adaptive management approach to be subject to ongoing independent expert review and suggested modifications. A panel of independent scientists (Panel) was convened to review the existing AM results and synthesis, as well as plans for future AM activities (draft 2012 Adaptive Management Plan, or AMP), to ensure these are of sufficient robustness and scientific quality to reliably serve their intended purposes.

The first wet year after the BiOp was issued was 2011, and thus an integrated set of studies was initiated (Fall Low Salinity Habitat, or FLASH studies) to provide information regarding the nature and mode of action of changes in the position of Fall Low Salinity Habitat and subsequent effects on DS health and abundance. The FLASH studies build on a package of special studies that were originally initiated in 2009-10. A draft of the FLASH study plan was contained within the 2011 Fall Outflow AMP and was reviewed by the Panel, which had also been convened by the Delta Science Program in 2011 prior to the 2011 Fall outflow event.

Results from the subsequent 2011 FLASH study are described in a draft 2012 FLASH study report. This report and additional presentations and supporting information were discussed during the Panel meeting on 31 July – 1 August, 2012. The agenda for the Panel meeting is included in Appendix II.

The current Panel report presented herein is based on the written information provided (Appendix I) and the discussions which occurred during the meeting (Appendix II). The questions posed to the Panel (Appendix I) were used to guide the

²X2 is the location (km) of the 2 ppt isohaline at estuary bottom, measured upstream from the Golden Gate bridge, as in Jassby et al. (1995).

discussion in general terms. The format of this report does not directly follow the questions posed to the Panel and thus Appendix I includes annotations that indicate which parts of this report address each of the questions in the Panel's original charge.

1.2 Progress Since the 2011 Review

The Panel was impressed by the level of coordination and research effort that the FLaSH team achieved in their study of the 2012 Fall outflow event. It was an impressive mobilization of field researchers that demonstrated professional, collegial collaboration among different research groups working toward a common goal. It was clear that several recommendations of the 2011 review Panel had been adopted while investigating this Action.

Given the complexity of the effort and the large amount of data collected, including many samples that required laboratory processing, the Panel was impressed by the amount of data presented in the written reports and presentations. It was clear in many instances that the research teams were gaining additional insights as they continued to share data among themselves. Analyses and discussion of the 2011 Fall outflow event will clearly continue for some time, and the Panel recognizes that learning from such an extensive effort will take time.

2. COMMENTS ON THE DRAFT 2012 FLaSH STUDY REPORT

The draft 2012 FLaSH study report focused on revision of the conceptual model (CM) for the AMP. The revised CM, which was described to the review panel in a presentation by Larry Brown (US Geological Survey), did an excellent job of integrating the many complex elements of previous models that were associated with the decline of the DS, and placed more-or-less equal weight on controls exerted by biotic and abiotic habitat processes. The Panel viewed this as a welcome modification, as previous descriptions of DS habitat use appeared to be too oriented toward abiotic parameters. Dr. Van Nieuwenhuyse (Bureau of Reclamation) in his remarks to the review panel succinctly framed the abiotic vs. biotic habitat issue as "physiology vs. food." In general, the revised CM was process-based rather than correlative, and was thus responsive to Recommendation 8 from the Panel's previous review:

"Reclamation should clearly articulate a conceptual model that explains the expected beneficial effect of the 2011 Fall Outflow manipulation on DS that includes cause-effect relationships rather than biogeophysical correlations alone. The proposed conceptual model will be the primary driver of the scientific questions to be addressed in the adaptive management plan."

However, the revised CM was presented as written text with associated hypothesis tests presented in tabular form, whereas the Panel was expecting a schematic version of the CM. While it is commonly argued that “box-and-arrow” schematic models can become overly complex and hard to interpret, especially when presented to agency board members and stakeholders, the Panel feels that a sufficiently complex schematic version of the CM needs to accompany the text-only version of the CM to help provide a visual representation of the dynamics, complexity, and interactions amongst all the parameters investigated. This is necessary for effective communication among Interagency Ecological Program (IEP) scientists and Panel members. Moreover, it is central to achieving an effective design for the AMP. The Panel also feels the CM needs to maintain a clear focus on the biology of the DS, particularly in regard to processes that affect vital parameters (growth, fecundity and mortality rates, with condition indicators being potentially useful as easily measured proxies for vital rates). Schematically, vital rates should be positioned at or near the ends of schematic pathways, as these determine population dynamics, which are in turn reflected in potential target metrics from ongoing trawl and tow-net surveys.

Recommendation 1: Develop a schematic version of the CM that matches the revised, written version of the CM in the draft 2012 FLaSH study report. The CM in written and schematic form should continue to emphasize processes and their interactions over statistical relationships, should ensure DS vital rates remain central to thinking, and should be designed for routine use by scientists as an organizational tool and for testing hypotheses associated with the AMP; it should be as complex as necessary to achieve these purposes. The CM should also be able to encompass processes and interactions that extend before and after Fall Outflow Action periods, including areas both upstream and downstream of the Low Salinity Zone (LSZ).

The level of resolution of the schematic version of the revised CM (i.e., a drawn “box and arrow” model) should match the resolution of the model’s written description as it appears in the draft 2012 FLaSH study report. The Panel believes a schematic version of the CM is essential to aid communications among researchers and managers inside and outside the FLaSH team. The schematic is not intended to replace the extensive narrative, but instead should summarize and communicate the knowledge therein.

In the schematic version of the CM, connecting arrows should be used to represent processes and linkages that can be tested using a hypothesis-based approach. Many processes and linkages can be evaluated using existing data and information. Processes and linkages that are found to be unsupported relative to others should be annotated as such in the schematic representation (e.g., by graying the arrows or other symbols that represent linkage). Processes or linkages that are found to be relatively unsupported by existing data or information should not be deleted from the model, but should instead be de-emphasized and provided with a system of annotation (footnote numbers or letters) that records the rationale behind the de-emphasis. This is necessary to preserve the rationale behind the CM, and also because it is possible that

de-emphasized processes or linkages will be revisited in the future after other competing processes and linkages have been evaluated, or as new information is obtained. It also allows those outside the team to recognize that other processes have been considered, not simply ignored. Processes and linkages that remain relatively viable and reflect the current understanding of the team should be evident in the resulting schematic version of the CM.

Future efforts can then evaluate remaining, relatively viable processes and linkages as hypotheses. These can be prioritized according to the hypotheses' expected importance as well as the relative ease of evaluation. Determinations of ease of evaluation should include an explicit effort to identify associated hypotheses that are not testable. Where possible, hypotheses that are not testable should be broken down into a set of interrelated testable hypotheses.

If a prioritized hypothesis cannot be evaluated using existing data or information, then special studies can be designed to allow evaluation. Many such special studies can be conducted during Non-Action years, providing *continuous advancement* to the accelerated learning process. Thus, all special studies that are related to the Fall Outflow action should lead to improvements to the CM. Whenever special studies support elaboration (or rejection) of existing hypotheses or the addition of new hypotheses to the CM, then such modifications should be evaluated for consistency with other relevant, existing data and information before new special studies are implemented to test them (as above). An up-to-date version of the schematic CM should be used to identify the position of all special studies in order to facilitate orientation to the CM by all parties engaged in addressing the needs of the RPA. Such updates to the schematic CM should be described in more detail within the supporting CM narrative. *These written and schematic descriptions will change as new information becomes available, yet nevertheless should strive to serve as representations of the best available science at any given point in time.*

3. COMMENTS ON THE ADAPTIVE MANAGEMENT PLAN

3.1 *General Strategy*

The goals of the AMP are (1) to manage Fall Outflow for conservation benefits to DS while minimizing water supply and water supply reliability impacts, and (2) to increase understanding about the effectiveness of Fall Outflow for DS conservation in order to adjust the Action for better conservation effect or water efficiency.

“The basic hypothesis at the foundation of the RPA is that greater outflows move the low salinity zone (LSZ, salinity 1-6), an important component of delta smelt habitat, westward and that moving the LSZ westward of its position in the Fall of recent years will benefit delta smelt, although the specific mechanisms providing such benefit are uncertain.” (from Draft 2012

FLaSH study report)

Recommendation 2: Begin a discussion of a definition of “success” for the Fall

Outflow action. Various partners in the DS AMP team should try to arrive at consensus on an appropriate target for DS population metrics or vital rates related to the Fall Outflow action. For instance, demographic trends for DS are well summarized in the draft 2012 FLaSH study report, but neither that report nor the proposed AMP contain a target population size or range of population sizes that would define success for this action alone or within the context of other actions being undertaken under the BiOp. This lack of a target will make it difficult to assess the long-term success of the program, especially in Action years when any positive demographic response of DS will need to be evaluated against the costs of reduced water availability for other uses. Would successful Action (in the smelt demographic sense) be represented by increasing DS numbers to 10%, 20% or 50% of historical numbers? Or is success defined as mere *persistence* of any number of DS over some time period? Even if this second, less ambitious target were to be the goal of the AMP, it should be explicitly stated so the AMP can be assessed in terms of smelt population dynamics and demography. An explicit definition of success will also be essential for evaluating both the annual and the longer-term performance and benefits of AM of Delta outflow, particularly in regard to the iterative aspects of the AMP (see page 74 of the Fall X2 AMP). Arriving at such an answer will presumably require some effort to be expended in trying to define a range of abundances that would encompass minimum viable population size for DS, and the consideration of this action in relation to other system manipulations.

Recommendation 3: Develop a simple decision matrix that identifies data collection and analysis objectives for Action years (wet and above normal years) and Non-Action years. The decision matrix should not necessarily be used only once per year, but should instead be designed to identify the earliest point in time at which commitments can be made to specific tasks. For example, planning for routine monitoring can start much earlier than planning for tasks that depend on recent outflow history, but it would be better to start planning for the latter as soon as the water year type is determined.

Recommendation 4: Use an interactive approach to develop long-term plans for monitoring and study during each water year type, and place a greater emphasis on integration of results in the AMP. Relationships within the CM should be evaluated across broad levels of variation (i.e., strive to obtain both end-member and intermediate observations). Examine existing data to determine how the distribution of observations can be improved for any given parameter. Ask “what processes do we need to learn about next?” and “can we get information during Non-Action years?” If the latter cannot be achieved, then the task becomes part of the plan for the next Action year. This type of interactive approach to data collection enables annual budget planning and will lead to long-term data collection efforts that are coordinated toward common goals. Note that data from Non-Action years will be critical to improving the

CM and the process of accelerated learning. Expect different years to have different data collection strategies.

Central to recommendations 3 and 4 will be a specific plan of action to integrate the results of the various studies in such a way as to produce answers to the basic question at the root of the AMP: how do the various abiotic and biotic factors act and/or interact to influence fundamental demographic parameters of DS critical to population persistence and recovery? (see following recommendation). The revised AMP document contains a series of quantitative model descriptions (in its Appendix II) that will apparently serve as the basis for the critical integration of abiotic and biotic data used to model smelt responses to flow management actions. This integration, however, is not well incorporated into the main document for the AMP. The words “integrate” and “integration” are used many times in the AMP, but not in the specific context of the material in the document’s Appendix II. This integration step, which is admittedly very dependent on data that may not yet have been collected, is critical to the entire exercise and especially to the evaluation step in the AM process. It should be better incorporated into the draft 2012 FLASH study report (e.g., what concrete steps have been taken to move towards integration of results?) and certainly within the revised AMP (i.e., not as just an appendix that is never cited).

Providing an explicit, long-term research plan will enhance the rigor of the science being conducted throughout the Delta. There should be specific criteria for actions designed prior to any water year or outflow condition in order to make the overall plan more scientifically defensible. Hydrological conditions and the designation of overall outflow categories (e.g., wet or above normal years) will be central to establishing the environmental criteria used to initiate specific actions, but it should also be recognized that other management issues may also factor into the scientific plan (e.g., periodicity of outflows, low dissolved O₂ events, harmful algal blooms, others). Timelines should be established that initiate research responses throughout hydrological years, as appropriate. Such planning requires a strong leader who can evaluate and prioritize input from a diversity of scientists and science publications (see Recommendation 7). The Panel firmly believes that an explicit research plan and experimental approach should be developed prior to the next series of research actions. Effective AM requires explicit initial environmental criteria in order to inform changes to future criteria.

3.2 Field Measurements

Recommendation 5: Determine where improvements to spatial or temporal resolution are warranted. The use of remote sensing, continuous recorders, and other means of obtaining higher-resolution data may reveal parameter variations that are not evident from monthly grab samples. Use the CM to focus on what is important to resolve in more detail (i.e., variables that are central to underlying hypotheses); however, do not needlessly expend resources on improving resolutions that are not

justified. Identify key locations for continuous measurements.

Recommendation 6: Identify opportunities to coordinate and integrate field measurements. The objectives of this effort are (1) to improve field sampling efficiencies and cost effectiveness and (2) to provide additional and complementary spatial and temporal resolution of linkages among the key physical, chemical, geological and biological parameters identified in the CM. These two objectives will help facilitate Recommendation 5.

Observations thus far reported on the fall 2011 X2 high flow period indicate substantial spatial and temporal heterogeneity in physical-chemical-biotic processes controlling biological activity, production, food availability and habitat supporting DS and other species in the SF Bay Delta. It appears that the “event scale,” that is, the frequency and distributions of episodic physical-chemical-biotic events (e.g., riverine discharge and wetland and saltmarsh flushing events, wind events), are strong determinants of the habitat condition and function that are essential for DS growth, reproduction, and protection from predation. It is therefore crucial that sampling strategies characterize and quantify the impacts of these events in an overall effort to capture physical-chemical-biotic interactions that are needed for understanding the linkage between drivers and responses controlling DS population dynamics.

Efforts should therefore be focused on optimizing high-frequency parallel collections of complementary process-level data to narrow and close the spatio-temporal informational gap that currently exists. Progress can be made by optimizing parallel collection/analysis of physical, chemical and biological data on cruises, and placement of continuous monitoring devices (e.g., multiprobe sondes, CTDs) in strategic locations that characterize the X2 area as well as areas upstream and downstream. Expanding sampling capabilities on cruises originally designated to measure specific sets of parameters (e.g., sediment characteristics, physical measurements) to include chemical (nutrient, organic constituents) and biological parameters (chlorophyll, phytoplankton) would be a cost-effective use of time and resources. This would require coordination with regard to facilitating the most effective and informative sampling frequencies as well as the subsequent handling and distribution of samples and data to relevant parties/projects. Employing graduate students focused on specific aspects of the X2 action to collect, transport, process and (in some cases) analyze samples would be a productive and cost-effective way of accomplishing such multi-parameter sampling. An added benefit is that students could use information obtained from this activity for their own thesis and dissertation projects.

Conducting multi-parameter, cross-disciplinary sampling will require coordination and communication among various research groups and individual investigators. However, there are multiple benefits to be gained from such activities. These activities will help clarify cause-and-effect relationships among physical-chemical-biotic drivers and responses. This will be of additional benefit for mechanistic (numerical) modeling efforts, which require information on quantitative relationships (for calibration and verification purposes) among these parameters. This effort will

also help elucidate controls on rate processes and assess the relative roles and importance (in time and space) of bottom up vs. top down controls on activity, structure and function of fish populations and associated communities, including prey and predators.

Lastly, multi-parameter studies will provide highly useful data for calibrating and verifying remote sensing information on co-occurring and frequently highly interactive physical-chemical-biological parameters, facilitating “scaling up” to the entire salinity gradient and ecosystem levels. Examples include the interaction of temperature, chlorophyll *a*, and turbidity along the salinity gradient; these are key parameters that have been used to determine/define DS habitat, food availability, activity and survival (from predation). Fortunately, these are also parameters that are among the most commonly detected and quantified by aircraft and satellite-based remote sensing platforms.

3.3 Long-Term Integration and Learning

Recommendation 7: Organize the leadership of the AMP. Determine who “owns” the AMP and its conceptual development (beyond the coordination of the field effort). Assign magnitude to the Action in terms of water costs and funding costs, and *identify and employ a Chief Scientist*. A person who serves as a common repository for information on field activities will facilitate the preceding recommendations.

The vast majority of successful group endeavors require a leader. Any enterprise of ecosystem-level adaptive management that incorporates multiple state and federal agencies, dozens of stakeholders, and hundreds of scientists, managers, and support staff also requires an effective leader. The DS AMP is one of the highest-profile and highest-impact ecosystem manipulations in the country (and likely the world). The geographical scale of this manipulation, the size of the population affected, and the economic ramifications are each very large in scale. Success or failure of the AMP will have long-lasting institutional effects on its major participants; scientific and civic accountability are both at stake.

The Panel cannot emphasize strongly enough that the AMP requires a strong leader who “champions” the project and agrees to serve singularly as Chief Scientist, coordinating experimental design, work allocation, data management, data integration, and conceptual synthesis. The Chief Scientist must be committed to a 10 year+ research agenda, have a broad and functionally deep understanding of hydrological, biogeochemical, and ecological aspects of the Delta, and have the authority to assemble needed scientific teams from participating state and federal agencies. The Chief Scientist should also be provided sufficient support staff; at a minimum, we suggest an administrative assistant and a database manager/statistician.

Leadership is essential for success and requires identification of a willing and competent candidate and suitable staff with competitive compensation. The Panel places high priority on the recruitment of this Chief Scientist and acquisition of

sufficient staff and resources to allow the Chief Scientist and the AMP to succeed.

Recommendation 8: Start planning now for future modeling needs. The ultimate goal of the AMP and associated research is improved prediction of biological response of DS in response to Delta outflow manipulation. However, development of numerical models is beyond the present scope and should be regarded as a parallel effort that will be supported by the improved CM. The improved CM will identify the key pathways and linkages that need to be modeled numerically, leading to integrated numerical modeling in the future. Whenever possible, participants in the AMP should plan beforehand for modeling needs that will arise in the future.

With regard to hydrodynamic modeling, it is necessary to produce model outputs in terms of variables that are be useful to other researchers (i.e., chemists, biologists) to enable them to link their findings with the system-flow dynamics more readily. These variables may include the minimum, average and maximum flow velocity in x and y directions, turbulent kinetic energy, and vorticity. These variables may help to identify the hydrodynamic conditions associated with DS success and they may each have distinct patterns of variability (see Figure 1 for hypothetical probability distribution function of hydrodynamic variables). Understanding the dynamics of more specific variables may help to evaluate key assumptions such as those of the draft 2012 FLaSH study report, which states *“Delta smelt may also benefit from the more variable hydrodynamics associated with the more complex bathymetry of the Suisun region which include more quiescent areas that may allow delta smelt to rest and feed in addition to areas with strong flows that delta smelt may utilize to move around the LSZ without expending large amounts of energy on swimming.”* Quantifying the hydrodynamics of the estuary in terms of the aforementioned variables or others may help to determine if the Suisun region is effectively the most dynamic region of the estuary. In addition, the results may help to identify other areas in the greater estuary that have spatiotemporal hydrodynamic patterns similar to those in the Suisun area.

This is one example of the very general terms used in the AMP to describe a wide array of potential conditions. Integration across disciplines will require specificity to enable clear communication, focus the data collection and modeling effort, and ensure the action is implemented efficiently and effectively.

Recommendation 9: Develop plans to account for uncertainty. Dynamic ecosystems mean uncertainty is always present, yet some parameters are more certain than others. AMP participants should design studies/monitoring that will reduce uncertainty, and account for uncertainty in assessments and predictions whenever possible.

During the presentation of “Salinity and flow structure and variations in Suisun Bay,” Mark Stacey demonstrated that the X2 parameter could move about 7 miles in a period of one week. As this parameter is highly variable, using X2 as the sole 'indicator' in assessments and predictions may introduce unnecessary uncertainty, and confusion among stakeholders. In addition to X2, parameters that have less variability should be

considered. One such parameter would be the horizontal area encompassing X2, which would be more stable than X2 itself.

The DoI technical guide to adaptive management (Williams et al. 2009) identifies *'assumption-driven research as central activities.'* In addition, Independent Science Advisors (2009) noted that research aimed at particular sources of uncertainty can be part of an adaptive management program. The Panel has identified a CM-based process where focused research (special studies) can be used to reduce uncertainty surrounding the Action and/or inform the implementation of future system manipulations. This general plan should be followed both to increase ecosystem understanding and to allow focused efforts to constrain uncertainty.

As identified in the DoI technical guide, reducing uncertainty is key to improving adaptive management. To reduce uncertainty, it is clearly necessary to identify the major sources of uncertainty. In an ideal scenario, enough data would be available to determine the range of conditions of various parameters assumed to be preferred by DS. In this ideal scenario, the probability distribution function (pdf) of the various parameters could be determined, including the temporal and spatial linkages between these parameters. The preferred range would be the mean value plus/minus a fraction or multiple of the standard deviation.

With relatively little data, one could still attempt to put together a graph similar to that in Figure 1. A plot like this may help to identify the regions where data are lacking and also help to identify sources of uncertainty. Once sources of uncertainty are identified, each individual source can be targeted with the aim of reducing uncertainty. As suggested in the DoI technical guide, uncertainty should be expressed as a set of competing, testable models whenever possible, so that an adequate monitoring system (e.g., adequate sample size and frequency) can be put in place with a reasonable expectation of reducing uncertainty. Poor monitoring precision can produce misleading evidence that can be counterproductive to the objectives of the AMP.

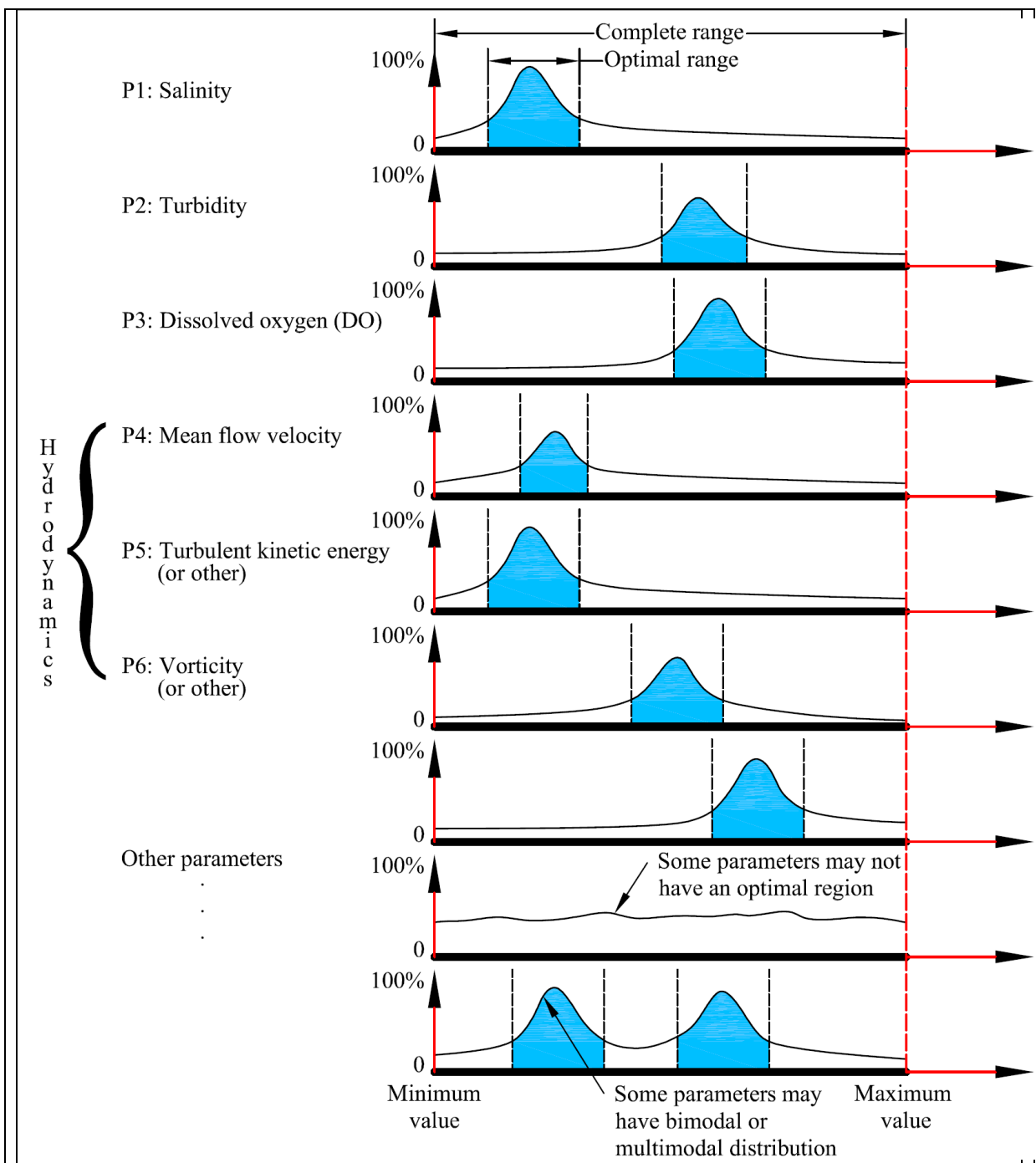


Fig. 1. Schematic probability distribution functions for various parameters. In this schematic, "x" axis changes for each parameter from its minimum to its maximum value and "y" axis changes from 0 to 100% or from 0 to 1 (Arturo Leon)

3.2 Response Variables

Recommendation 10: The AMP should incorporate monitoring of response variables that have a clear demographic linkage to DS, both at the individual and population level (e.g., otolith inferred growth rates, fecundity, condition factor). This is a restatement of an important recommendation (No. 14) from the previous Panel report.

The status of the DS is entirely dependent on its population dynamics; thus, understanding causes of variation in the vital rates (growth, fecundity, mortality) that influence population dynamics is of primary importance to the goals of the RPA and the manner in which the AMP is modified to meet the goals of the RPA. In addition to vital rates, condition factors can also be highly relevant because they serve as practical surrogates for vital rates. Lifetime reproductive potential is a useful concept here, where the total number of eggs produced by an average female is a function of growth rate (which determines the time required to reach the larger sizes that generally produce more eggs), female energetic condition and health (which relates to size-specific fecundity), and mortality rate (which affects the average number of spawning bouts in which females can participate).

Hypotheses that have the potential to explain variation in these vital rates are therefore directly relevant to the CM and its objectives. Documenting anomalies in vital rates, coupled with investigations of associated environmental conditions, is a potentially fruitful approach to discovering the most important factors that affect population dynamics, minimum viable population sizes, and the probability of achieving recovery (however defined, see Recommendation 2) of DS.

4. PERSPECTIVES ON SPECIAL STUDIES

The Panel was presented with results of a number of special studies, yet many studies are either ongoing or were not presented due to lack of time and will be considered in future reviews. The following are considerations rather than recommendations.

4.1 Turbidity Studies

Data presented by the USGS during the review illustrated the clear decline in turbidity that has occurred in recent decades in general coincidence with the pelagic organism decline (POD) period (Maureen Downing-Kunz, USGS). Data presented separately

by Bryan Downing (USGS) illustrated the strong nonlinear relationship between turbidity and the depth of the euphotic zone. Together, these observations indicate the surface area available for epiphytic or benthic microalgal growth has been increasing on a similar decadal scale (epiphyte habitat includes the euphotic sections of emergent wetland grasses as well as equivalent areas on submerged aquatic vegetation). The Panel was surprised to find no obvious consideration of the broader ecological changes which could result from these abiotic trends.

4.2 Trophic Analyses

As indicated in the previous (2011) Panel report, the commonly held idea that pelagic fishes depend entirely on phytoplankton as a basal resource has been challenged by Vander Zanden and Vadeboncoeur (2002), Rooney et al (2006), and others. Periods of high phytoplankton productivity are typically sporadic, with low-productivity periods being interspersed among individual phytoplankton bloom events. During these low-productivity intervals, predation on benthic organisms may bridge gaps between phytoplankton blooms. The carbon that supports benthic organisms may be either planktonic (i.e., phytoplankton or phytodetritus) or benthic in origin (benthic microalgae and plants). The throughputs of carbon through complex benthic communities and into pelagic fishes may be lower (less efficient) than the throughputs associated with plankton blooms, but dependence on these “slow” benthic channels can nevertheless determine survival probabilities at both the individual and population levels. For example, tunas are classically depicted as being phytoplankton-dependent, yet Rooney et al. (2006) and others have found that tunas on the continental shelf may derive large proportions of their diets from benthic pathways. This counterintuitive finding is explained by the tunas’ predation on squids that consume benthic crustaceans. Likewise, diet studies have identified spatiotemporally inconsistent, yet substantive, contributions of mysids and gammaridean amphipods to DS diets. Mysids, gammaridean amphipods and other peracarid crustaceans have strong associations with bottom substrates and are commonly considered to be hyperbenthic, rising into the water column at night and during certain tidal stages. Unless these peracarids derive their biomass entirely from phytoplankton (whether suspended or sedimented), then more than one basal resource supports the DS, and more than one basal resource should be considered by the CM. This is a fundamental concern that lies at the core of the CM.

A closely related concept is presented in Fig. 2 of Vander Zanden and Vadeboncoeur (2002), wherein the diet of lake trout becomes more dependent on zoobenthos as the ratio of lake surface area to shoreline length decreases. Individuals in large lakes depend on plankton as a basal resource, whereas those in small lakes depend more on zoobenthos. This has potential relevance to fluctuating volumes, areas and shoreline lengths associated with the lower-Delta LSZ, which are directly influenced by outflows and will be correlated with X2 to some degree. Unless the DS has a facultative response to basal resource availability similar to some species in Fig. 1 of

Vander Zanden and Vadeboncoeur (2002), then temporal shifts in the size of habitat may have implications for trophic inefficiency. In this scenario, fluctuations in basal-resource dependence (and associated trophic inefficiencies) will result in some species being “winners” and others being “losers.” Mean X2 may be a proxy for these general effects, but the extent of variation in X2 about its mean value may also have implications. Scientists and water managers should also recognize that identical target values for the Action (i.e., mean X2) can be obtained using a variety of different outflow hydrograph patterns, and that differences in these outflow patterns will have different effects on water supply, DS, and overall ecosystem impact.

The Review Panel was presented with evidence of phytoplankton accumulations (standing biomass) upstream and downstream of the lower-Delta LSZ, but not within the lower-Delta LSZ, keeping the processes that make this area productive for DS somewhat obscure. Verbal comments by Jan Thompson (USGS) about Grizzly Bay being well suited to phytoplankton production/accumulation are relevant to this topic, but the Panel has yet to see direct evidence of this phenomena.

5. SUMMARY CONCLUSIONS

Although the Panel found no fatal errors in the scientific approach, nine new recommendations were developed:

1. Develop a schematic version of the CM that matches the revised, written version of the CM in the draft 2012 FLaSH study report.
2. Begin a discussion of a definition of “success” for the Fall Outflow action.
3. Develop a simple decision matrix that identifies data collection and analysis objectives for Action years (wet and above normal) and Non-Action years.
4. Use an interactive approach to develop long-term plans with common goals, and place a greater emphasis on integration of results in the AM plan.
5. Determine where improvements to spatial or temporal resolution are warranted.
6. Identify opportunities to coordinate and integrate field measurements.
7. Organize the leadership of the AMP.
8. Start planning now for future modeling needs.
9. Develop plans to account for uncertainty.

The Panel also reiterated its 2011 recommendation that the AMP should incorporate monitoring of response variables that have clear demographic linkages to DS both at the individual and population level (e.g., otolith inferred growth rates, fecundity, condition factor). Some issues identified in the previous Panel review remain unresolved. Most importantly, adaptive management of outflows will only be successful if the required coordination among agencies is complete, which includes a commitment to providing appropriate leadership in the form of a single individual who possesses broad ecosystem knowledge. As pointed out by the previous Panel review, shortcomings in other adaptive management initiatives have been associated with a lack of leadership and failure to provide the time and energy required for effective plan development and implementation (Walters 2007). The Panel urges leadership at all participating agencies to be responsive to requests for resources, especially time commitments from the agencies’ most qualified scientists and managers.

Much more detail is still required concerning the mechanics of flow manipulation in order to determine the feasibility of *how* flow is to be manipulated. The IEP scientists should functionally connect event monitoring data and assessments from

before, during and after-release events, and should continue to recognize that the Action will impact multiple species and biogeochemical processes over varying spatial and temporal scales. In other words, examine the Fall Outflow Action within broader contexts. Scientists and water managers should also recognize that identical target values for the Action (i.e., mean X2) can be obtained using a variety of different outflow hydrograph patterns, and that differences in these outflow patterns will have different effects on water supply, DS, and overall ecosystem impact. The key objective of the AMP is to cause desirable biotic and abiotic conditions to coincide with larger areas or volumes of potential habitat, and to then determine how the DS population responds.

6. REFERENCES

Independent Science Advisors. 2009. Bay Delta Conservation Plan Independent Science Advisors' Report on Management, prepared for the BDCP Steering Committee, February 2009. Available at:

http://baydeltaconservationplan.com/Libraries/Background_Documents/BDCP_Adaptive_Management_ISA_report_Final.sClb.ash. (accessed April 11, 2011).

Jassby, A. D., W.J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. *Ecological Applications* 5: 272-289. DOI: 10.2307/1942069

Rooney, N., K. McCann, G. Gellner and J. C. Moore. 2006. Structural asymmetry and the stability of diverse food webs. *Nature* 442:265-269.

Vander Zanden, M. J. and Y. Vadeboncoeur. 2002. Fishes as integrators of benthic and pelagic food webs in lakes. *Ecology* 83:2152-2161.

Walters, C.J. 2007. Is adaptive management helping to solve fisheries problems? *Ambio* 36: 304-307.

Williams, B. K., R. C. Szaro and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Appendix I

Scientific Review Panel Charge and Materials

**DELTA SCIENCE PROGRAM
INDEPENDENT SCIENCE REVIEW**

Adaptive Management Plan for Delta Fall Outflow

1. REVIEW PANEL CHARGE

The Review Panel was charged with assessing the Plan for Adaptive Management of Delta Fall Outflow from several points of view, with emphasis on the use of the Plan as an adaptive management tool. The Charge is repeated here with summary points relating each question to the response within the main Panel report.

FLaSH-related Learning:

- What are the major results associated with the data collection conducted during the first year of the plan implementation?
 - The Panel heard important results regarding DS abundance and condition, turbidity and food web dynamics. However, it was clear that only a portion of the results were available for presentation to the Panel at the meeting.
- Do the results support the scientific basis of the Fall Outflow Action?
 - Yes. Analyses were presented that support the fundamental DS life-history model underlying the action (re: presentations by Teh and Baxter/Slater).
- Have the recommendations from the 2011 Science Panel been appropriately addressed or incorporated into ongoing studies and their interpretation?
 - It was clear that efforts had been made to incorporate Panel recommendations.

Adaptive Management Plan:

- Do the goals of the AMP remain consistent with the goals of the RPA?
 - Yes, insofar as they were presented to the Panel.
- How well will the AMP, as designed, meet its two major goals: (1) to manage Fall outflow for conservation benefits to delta smelt while minimizing water supply and water supply reliability impacts; (2) to increase the effectiveness of Fall outflow for smelt conservation in order to adjust the Action for better effect and/or water efficiency?
 - See Panel recommendations regarding improvements which could be made.
- Are AMP updates justified and defensible?

- See Panel recommendations regarding improvements which could be made.
- Is the plan internally consistent and scientifically valid given the first year of data collection?
 - See Panel recommendations regarding improvements which could be made.
- Will continued implementation of the plan adequately provide the information necessary for refining the goals and objectives, knowledge base and models, and approach of the plan over time?
 - Yes, if the recommendations of the Panel are fully implemented.

Approach:

- Is the use of hypotheses, conceptual models and quantitative models clear and helpful? If not, how might this be changed or refined?
 - See Panel recommendations regarding improvements which could be made.
- Will the ongoing monitoring and evaluation program result in adequate detection of signal to noise (inherent variability)?
 - See Panel recommendations regarding consideration of uncertainty.
- Will the likelihood of drier conditions in 2012 necessitate data collection or analysis revision?
 - Yes. See Panel recommendations regarding planning for different year types.
- How could the ongoing monitoring and evaluation program be changed or refined to allow for a more rapid assessment of the goals of the RPA?
 - See Panel recommendations regarding long-term planning, integration and leadership.
- Does the plan contain adequate provision for synthesis, evaluation, and reporting?
 - See Panel recommendations regarding the use of the CM as a means to communicate learning.
- Are there other recommendations or ideas that Reclamation should consider for the program?
 - See Panel recommendations
- The tendency in an evolving process is to expand and enhance existing monitoring/analysis. To ensure the most efficient use of resources, are there any elements of the AMP that are redundant or of marginal value.
 - The Panel did not identify any elements that are redundant or of marginal value.

Feasibility:

- Is the approach described in the plan feasible to implement?
 - Yes, if Panel recommendations for improvement are implemented.
- If not, what can be done to improve feasibility of the approach?

- See Panel recommendations regarding approach.

2. REVIEW MATERIALS

The Panel reviewed in detail the following documents:

- Draft 2012 FLaSH study report
- Draft 2012 Plan for Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability

3. SUPPORTING INFORMATION

The following materials were available to the Panel to assist with its review:

- USGS Peer review Scope
- Delta Science Program – Review Panel Summary Report: Draft Plan for Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability (July 2011)
- Reclamation’s summary and other responses to the recommendations made by the 2011 DSP Review Panel (available June 30, 2012)
- DOI Technical Guide
<http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf>
- A 2-page description of new data analysis and synthesis effort conducted by the Interagency Ecological Program’s new Management, Analysis, and Synthesis Team (MAST).
- IEP call for study concept proposals and study concept and proposal review guidelines released June 2012.
http://www.water.ca.gov/iep/docs/2012_Study_Concept_Proposal_Review_Guidelines_1.pdf
- Final 2010 POD Report
<http://www.water.ca.gov/iep/docs/FinalPOD2010Workplan12610.pdf>
- Coordinated Operations Biological Opinion (USFWS 2008) RPA Component 3 and associated explanatory material in the RPA and BiOp. http://www.fws.gov/sacramento/es/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf
- Independent Review of Two Sets of Proposed Actions for the Operations Criteria and

Plan's Biological Opinion (PBS&J, 2008)

<http://www.fws.gov/sfbaydelta/documents/Peer%20review%20of%20proposed%20actions%2011-19-08.pdf>

- NRC March 2010 Panel Report http://www.nap.edu/catalog.php?record_id=12881
- NRC March 2012 Panel Report http://www.nap.edu/catalog.php?record_id=13394

4. COMMENTS

The following comments were made available to the Panel for its review:

- [Comments from the State and Federal Contractors Water Agency - "An appraisal of the relationship of delta smelt population dynamics and the position of the low-salinity zone in the San Francisco estuary – why the Delta Smelt Biological Opinion is not based on the “best available science” \(July 2nd 2012\)](#)
- [Comments from the State and Federal Contractors Water Agency - "On the Fall X2 Adaptive Management Plan \(Milestone Draft\) for the Review Panel" \(July 2nd 2012\)](#)
- [Comments from the Coalition for a Sustainable Delta with attachments \(July 25th 2012\)](#)

5. PRESENTATIONS

The following technical presentations were given to the Panel and audience during the meeting (July 31, 2012):

- Implementation of the 2011 Fall Outflow Adaptive Management Plan (Anke Mueller-Solger, IEP Lead Scientist)
- Draft 2012 Fall Outflow Adaptive Management Plan (Erwin Van Nieuwenhuysse, U.S. Bureau of Reclamation)
- Year 1 FLaSH Studies synthesis and overview (Larry Brown, U.S. Geological Survey)
- Salinity and flow structure and variations in Suisun Bay (Stephen Monismith, Stanford, and Mark Stacey, UC Berkeley)
- Suspended sediment in the low salinity zone (Maureen Downing-Kunz, USGS)
- FLaSH work update, including present and ongoing work in Liberty Island and work relative to Delta dissolved organic matter, mercury, nutrient and particle characterization (Bryan Downing, USGS)

- Differences in isotopes, chemistry, and hydrology for sites and dates sampled fall 2006 and 2011 (Carol Kendall, USGS)
- Nutrient and phytoplankton distributions during the fall low salinity habitat (FLaSH) study in Suisun Bay (Alex Parker, San Francisco State University (SFSU))
- *Corbicula* and *Potamocorbula* biomass, grazing, and recruitment patterns in May & October (Jan Thompson, USGS)
- Update on experiments with *Corbula* and *Potamocorbula* (Nate Miller/Jonathon Stillman, SFSU)
- Fish FLaSH and delta smelt diets (Randy Baxter/Steve Slater, Department of Fish and Game)
- Health and reproductive performance of adult delta smelt (Swee Teh, UC Davis)

Appendix II

Agenda for Independent Science Review



July 17, 2012

-Meeting Notice-

Delta Science Program Independent Science Review

Fall Low Salinity Habitat (FLaSH) Study Synthesis – Year One of the Delta Fall Outflow Adaptive Management Plan

July 31, 2012, 8:30 a.m. - 4:30 p.m.
August 1, 2012, 1:00 p.m. - 4:45 p.m.

Meeting Location:

980 9th Street
Park Tower 2nd Floor Conference Center
Sacramento, California 95814

Purpose: A panel of independent scientists will convene to review the draft FLaSH report, synthesizing what was learned from implementing the 2011 Delta Fall Outflow Adaptive Management Plan to assess its scientific quality. The panel will also review the draft 2012 Fall Outflow Adaptive Management Plan.

AGENDA

Order of agenda items and listed times are subject to change.

Day 1: July 31, 2012 – (8:30 a.m. – 4:30 p.m.)

I. Introduction

- | | |
|-------------|------------------------------------------------------------------------------------------------------------|
| 8:30 - 8:45 | Welcome Remarks (Peter Goodwin, Delta Science Program Lead Scientist) |
| 8:45 - 9:00 | Implementation of the 2011 Fall Outflow Adaptive Management Plan (Anke Mueller-Solger, IEP Lead Scientist) |

II. FLaSH Study Presentations

- | | |
|-------------|-------------------------------------------------------------------------------------------------------|
| 9:00 - 9:30 | Draft 2012 Fall Outflow Adaptive Management Plan (Erwin Van Nieuwenhuyse, U.S. Bureau of Reclamation) |
|-------------|-------------------------------------------------------------------------------------------------------|

"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

– State Water Code §85054

9:30 - 10:15	Year 1 FLaSH Studies synthesis and overview (Larry Brown, U.S. Geological Survey (USGS))
10:15 - 10:30	Break
10:30 - 12:00	Abiotic Habitat Components <ul style="list-style-type: none"> • Salinity and flow structure and variations in Suisun Bay (Stephen Monismith, Stanford, and Mark Stacey, UC Berkeley) • Suspended sediment in the low salinity zone (Maureen Downing-Kunz, USGS) • FLaSH work update, including present and ongoing work in Liberty Island and work relative to Delta dissolved organic matter, mercury, nutrient and particle characterization (Bryan Downing, USGS) • Differences in isotopes, chemistry, and hydrology for sites and dates sampled fall 2006 and 2011 (Carol Kendall, USGS)
12:00 - 1:00	Lunch
1:00 – 2:00	Biotic Habitat Components <ul style="list-style-type: none"> • Nutrient and phytoplankton distributions during the fall low salinity habitat (FLaSH) study in Suisun Bay (Alex Parker, San Francisco State University (SFSU)) • <i>Corbicula</i> and <i>Potamocorbula</i> biomass, grazing, and recruitment patterns in May & October (Jan Thompson, USGS) • Update on experiments with <i>Corbula</i> and <i>Potamocorbula</i> (Nate Miller/Jonathon Stillman, SFSU)
2:00 – 2:45	Delta Smelt Responses <ul style="list-style-type: none"> • Fish FLaSH and delta smelt diets (Randy Baxter/Steve Slater, Department of Fish and Game) • Health and reproductive performance of adult delta smelt (Swee Teh and students/staff, UC Davis)
2:45 - 3:00	Break

III. Discussion

3:00 - 4:00 Panel/Presenter Question and Answer Session

IV. Public Comment

4:00 - 4:30 Public comments

Public comment will be limited to 3 minutes per speaker. Comments must be relevant to the science review.

4:30 p.m. Adjourn

Day 2: August 1, 2012 – (1:00 p.m. – 4:45 p.m.)

I. Presentation of Panel's Initial Findings/Recommendations

1:00 - 3:00 Panel Presents and Discusses its Initial Findings and Recommendations with Presenters from the Previous Day

3:00 - 3:15 **Break**

3:15 - 4:00 Panel and Presenter Discussion Continued

II. Public Comment

4:00 - 4:30 Public Comments on the Science Review

Public comment will be limited to 3 minutes per speaker. Comments must be relevant to the science review

4:30 - 4:45 Next steps – Delta Science Program

4:45 p.m. Adjourn

-
- If you have any questions, please contact George Isaac at (916) 445-0533 or gisaac@deltacouncil.ca.gov
 - Members of the public are encouraged to visit the Delta Science Program website for the meeting materials. A limited number of copies of these materials will be available at the meeting.
 - Reasonable time limits may be established for public comments (Government Code Sections 11125.7). If you need reasonable accommodation due to a disability, please contact Debbie Mininfield, Delta Stewardship Council at (916) 445-5511, TDD (800) 735-2929.